

Listing of the Claims

1. (Original) A process for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant properties of one or more substrates having one or more flame retardant properties, comprising:

(a) applying a flame retardant composition to one or more substrates in an amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates, wherein the substrates contain at least about 5 weight percent of non-thermoplastic material;

(b) removing excess flame retardant composition from the substrates;

(c) optionally, rinsing the substrates with an amount of a rinse liquid that is sufficient to remove any remaining flame retardant composition that is not necessary or beneficial for providing one or more flame retardant properties to the substrates, or for enhancing one or more flame retardant properties of the substrates;

(d) optionally, removing excess rinse liquid from the substrates;

(e) permitting the substrates to dry for a period of time, and at a temperature, that permits the substrates to have a low moisture content; and

(f) applying at least some of the excess flame retardant composition that is removed from the substrates to:

(1) one or more of the same substrates at least one additional time prior to, at the same time as, or after the substrates are permitted to dry; or

(2) one or more other substrates of the same or different type; in an amount that is sufficient to provide one or more flame retardant properties to such substrates, or to enhance one or more flame retardant properties of such substrates;

wherein the flame retardant composition comprises a mixture of:

(1) one or more flame retardant substances in a combined amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates;

(2) an aqueous or non-aqueous liquid in an amount that is sufficient to permit the flame retardant substances to be applied to the substrates in a manner that provides one or more flame retardant properties to the substrates, or enhances the flame retardant properties of the substrates;

(3) one or more adhesion agents in a combined amount that is sufficient to permit the flame retardant substances to become adhered, or to enhance the adhesion of the flame retardant substances, to one or more surfaces, areas or components of the substrates;

(4) optionally, one or more stability enhancing agents in a combined amount that is sufficient to provide at least some stability to, or enhance the stability of, the flame retardant composition;

(5) optionally, one or more viscosity enhancing agents in a combined amount that is sufficient to increase the viscosity of the flame retardant composition; and

(6) optionally, one or more wetting agents in a combined amount that is sufficient to enhance an ability of the flame retardant composition to penetrate into, or to spread over, one or more surfaces, areas or components of the substrates;

wherein neither the flame retardant composition nor any rinse liquids contain an amount of a dye or other agent that could contaminate the process.

2. (Original) A process of claim 1 wherein the substrates are not separately baked or cured after they are dried.

3. (Original) A process of claim 1 wherein the substrates are not rinsed after excess flame retardant composition is removed from the substrates.

4. (Original) A process of claim 1 wherein the process provides substrates that are durable.

5. (Original) A process of claim 1 wherein the flame retardant composition saturates the substrates.
6. (Original) A process of claim 5 wherein the flame retardant composition is applied to the substrates using a soaking, immersion, drenching, dipping or impregnation method.
7. (Original) A process of claim 1 wherein all of the excess flame retardant composition is recycled and provides one or more flame retardant properties to one or more substrates, or enhances one or more flame retardant properties of one or more substrates.
8. (Original) A process of claim 1 wherein the flame retardant composition does not contain any dye, and does not contain any other chemical compound, substance, agent or composition that could contaminate the process.
9. (Original) A process of claim 6 wherein excess flame retardant composition is removed from the substrates by separating the substrates from the excess flame retardant composition, by centrifuging the substrates, by squeezing the substrates or using a combination or more than one of the foregoing techniques.
10. (Original) A process of claim 1 wherein the aqueous or non-aqueous liquid is an aqueous liquid, the one or more flame retardant substances are phosphoric acid, halogen-free phosphoric acid derivatives, phosphonic acid, halogen-free phosphonic acid derivatives, ammonium polyphosphate, ammonia, ammonia phosphate, ammonium molybdate, ammonium borate, organophosphorus chemicals, melamine, melamine chemicals, intumescent chemicals, alumina trihydrate, urea, guanidine, dicyandiamide, ethyl urea, ethylamine, thiourea, diethylenediamine, ethylenediamine, brominated aromatic organic compounds or brominated cycloaliphatic organic compounds, and the adhesion agent is a cross-linking binder or a polymer or copolymer of an ester of acrylic acid, methacrylic acid, a styrene butadiene copolymer, vinyl chloride, vinylidene

chloride, vinyl acetate, acrylonitrile, an acrylamide or a polyurethane ester or ether.

11. (Original) A process of claim 1 wherein the substrates are filaments, microfibers, fibers, fibrous compositions, threads, yarns, fabrics, textiles or a blend of any of the foregoing materials.

12. (Original) A process of claim 11 wherein the substrates are filaments, microfibers, fibers, fibrous compositions, threads, yarns, fabrics or textiles.

13. (Original) A process of claim 12 wherein the substrates are filaments, microfibers or fibers.

14. (Original) A process of claim 6 wherein the substrates are filaments, microfibers or fibers.

15. (Original) A process of claim 14 wherein the substrates are fibers.

16. (Original) A process of claim 12 wherein the substrates are fabrics.

17. (Original) A process of claim 11 wherein the substrates contain from about 20 to about 100 weight percent of non-thermoplastic material.

18. (Original) A process of claim 17 wherein the substrates contain about 100 weight percent of non-thermoplastic material.

19. (Original) A process of claim 18 wherein the substrates are non-thermoplastic filaments, microfibers or fibers.

20. (Original) A process of claim 12 wherein the substrates are rayon or cotton fibers, fibrous compositions or fabrics.

21. (Original) A process of claim 20 wherein the substrates are rayon or cotton fibers.
22. (Original) A process of claim 10 wherein and the pH of the flame retardant composition ranges from about 2 to about 11, and the viscosity of the composition ranges from about 50 to about 1,500 centipoises.
23. (Original) A process of claim 12 wherein substrates treated with the process are formed into, or used as, a flame barrier substrate, and wherein the flame barrier substrate has the ability to provide at least some protection against combustion to an adjacent material or substrate that does not have any flame retardant properties.
24. (Original) A process of claim 23 wherein the flame barrier substrate is a fibrous composition, a textile or a fabric.
25. (Original) A process of claim 24 wherein the flame barrier substrate is a non-woven fibrous composition.
26. (Original) A process of claim 25 wherein the flame barrier substrate is employed as a component of a pillow-top or other mattress, a pillow or a cushion.
27. (Original) A process of claim 10 wherein the crosslinking binder is polyvinyl acetate, a formaldehyde polyacrylate, a polyurethane, a urea-formaldehyde, a polyepoxide resin or a melamine formaldehyde, and the flame retardant substance is a brominated aromatic compound or a brominated cycloaliphatic compound.
28. (Original) A process of claim 12 wherein the substrates are flax, kenaf, ramie, caroa, bagasse, ficque, banana, cotton, linen, jute, coconut fiber, rayon or hemp fibers, fabrics or fibrous compositions.
29. (Original) A process of claim 5 wherein the substrates are fibers, and wherein the treated fibers are subsequently blended with one or more other fibers that do

not have any flame retardant properties to produce a homogeneously blended product.

30. (Original) A process of claim 1 wherein the process is environmentally friendly.

31. (Original) A process of claim 1 wherein the cost of the flame retardant substances employed is reduced by at least about 75% in comparison with an open loop flame retarding process that employs the same flame retardant substances and the same amounts thereof.

32. (Original) A process of claim 1 wherein the cost of the flame retardant substances employed is reduced by at least about 90% in comparison with an open loop flame retarding process that employs the same flame retardant substances and the same amounts thereof.

33. (Original) A process of claim 1 wherein the treated substrates have a flame retardant coating on one or more surfaces, areas or components thereof that reduces the amount of burning that occurs to the substrates, or the amount or density of smoke produced by the substrates, when the substrates are exposed to a flame in comparison with the same substrates that have not been treated in this manner.

34. (Original) A process of claim 33 wherein the treated substrates have the ability to pass the requirements of the NFPA 701 test.

35. (Original) A process of claim 34 wherein the treated substrates undergo the NFPA 701 test, and that NFPA 701 test shows that a char length of the treated substrates is less than about 3 inches and that no afterflame is produced.

36. (Original) A process of claim 10 wherein the one or more flame retardant substances are in a solid particulate form at room temperature.

37. (Original) A process of claim 36 wherein the flame retardant substances have an average particle size ranging from about 1 to about 200 microns.

38. (Original) A process of claim 1 wherein the combined amount of flame retardant substances ranges from about 0.5 to about 75 weight percent of the flame retardant compositions, the amount of the aqueous or non-aqueous liquid ranges from about 0.5 to about 70 weight percent of the flame retardant compositions, the combined amount of adhesion agent ranges from about 0.5 to about 0.7 weight percent of the flame retardant compositions, and the viscosity of the flame retardant compositions ranges from about 50 to about 1,500 cps.

39. (Currently amended) A process for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant properties of one or more substrates having one or more flame retardant properties, comprising:

- (a) applying a flame retardant composition to one or more substrates in an amount that is sufficient to provide one or more flame retardant properties to the substrates, or to enhance one or more flame retardant properties of the substrates, wherein the substrates contain at least about 5 weight percent of non-thermoplastic material;

- (b) removing excess flame retardant composition from the substrates;

- (c) optionally, rinsing the substrates with an amount of a rinse liquid that is sufficient to remove any remaining flame retardant composition that is not necessary or beneficial for providing one or more flame retardant properties to the substrates, or for enhancing one or more flame retardant properties of the substrates;

- (d) optionally, removing excess rinse liquid from the substrates;

- (e) permitting the substrates to dry for a period of time, and at a temperature, that permits the substrates to have a low moisture content; and

- (f) applying at least some of the excess flame retardant composition that is removed from the substrates to:

- (1) one or more of the same substrates at least one additional time prior to,

at the same time as, or after the substrates are permitted to dry; or

(2) one or more other substrates of the same or different type;

in an amount that is sufficient to provide one or more flame retardant properties to such substrates, or to enhance one or more flame retardant properties of such substrates ~~substrats~~.

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78. (Currently amended) A method for reducing the burning of, or the amount or density of smoke produced by, one or more substrates containing at least about 5 weight percent of non- thermoplastic material that is exposed to a flame comprising applying a flame retardant composition comprising:

(1) one or more flame retardant substances in a combined amount that is sufficient to provide one or more flame retardant properties to one or more substrates, or to enhance one or more flame retardant properties of one or more substrates, wherein the substrates contain at least about 5 weight percent of non-thermoplastic material;

(2) an aqueous or non-aqueous liquid in an amount that is sufficient to permit the flame retardant substances to be applied to the substrates in a manner that provides one or more flame retardant properties to the substrates, or enhances the flame retardant properties of the substrates;

(3) one or more adhesion agents in a combined amount that is sufficient to permit the flame retardant substances to become adhered, or to enhance the adhesion of the flame retardant substances, to one or more surfaces, areas or components of the substrates;

(4) optionally, one or more stability enhancing agents in a combined amount that is sufficient to provide at least some stability to, or enhance the stability of, the flame retardant composition;

(5) optionally, one or more viscosity enhancing agents in a combined amount that is sufficient to increase the viscosity of the flame retardant composition; and

(6) optionally, one or more wetting agents in a combined amount that is

sufficient to enhance an ability of the flame retardant composition to penetrate into, or to spread over, one or more surfaces, areas or components of the substrates;

wherein the flame retardant composition does not contain an amount of a dye or other chemical compound, agent, substance or composition that could prevent the flame retardant composition from producing the same or very similar results between its application to the substrates and, after it has been applied to the substrates, its application at least one time to

(a) one or more of the same substrates; or

(b) one or more other substrates of the same or different type;

wherein the flame retardant composition has an ability to provide one or more flame retardant properties to one or more substrates that contain at least about 5 weight percent of non-thermoplastic material and that have no flame retardant properties, or to enhance one or more flame retardant properties of one or more substrates that contain at least about 5 weight percent of non-thermoplastic material and that have one or more flame retardant properties, without containing a metal oxide, when it is first applied to one or more substrates and also after it has been applied to one or more substrates;

and wherein the flame retardant composition can be applied to the substrates in a "closed loop" process or system for providing one or more flame retardant properties to one or more substrates having no flame retardant properties, or for enhancing one or more flame retardant properties of one or more substrates having one or more flame retardant properties,

of claim 75 to the one or more substrates at least one time prior to the substrates being exposed to the flame.

79. (New) A process for applying a flame retardant composition to a first and second substrate having at least a 5 weight percent of non-thermoplastic material, the process comprising:

treating the first substrate in a first treatment vessel with the flame retardant composition;

transferring a first unused portion of the flame retardant composition from

the first treatment vessel to a second treatment vessel;

removing a first excess portion of the flame retardant composition from the first substrate;

drying the first substrate to a first desired moisture content;

treating the second substrate in a second treatment vessel with the first excess portion of the flame retardant composition;

transferring a second unused portion of the flame retardant composition from the second treatment vessel to the first treatment vessel;

removing a second excess portion of the flame retardant composition from the second substrate; and

drying the second substrate to a second desired moisture content.

80. (New) The process of claim 79, further comprising forming the flame retardant composition by mixing a plurality of substances in a collection tank before treating the first substrate with the flame retardant composition .

81. (New) The process of claim 80 wherein mixing a plurality of substances includes:

mixing a flame retardant substance;

mixing a solvent compatible with the first and second substrates, the solvent having a quantity sufficient to mix the flame retardant substance; and

mixing an adhesion agent having a quantity sufficient to adhere the flame retardant substance to the first and second substrates.

82. (New) The process of claim 80, wherein mixing a plurality of substances further includes:

mixing at least one of a stability agent;

mixing a viscosity enhancing agent; and

mixing a wetting agent.

83. (New) The process of claim 80, further comprising transferring the first excess portion to the collection tank, after removing the first excess portion.

84. (New) The process of claim 80, further comprising transferring the second excess portion to the collection tank, after removing the second excess portion.

85. (New) The process of claim 79, further comprising:

rinsing the first substrate with a rinse liquid, after the step of removing the first excess portion of the flame retardant composition from the first substrate and before the step of treating the second substrate with the first excess portion of the flame retardant composition; and

removing an excess rinse liquid from the first substrate, after the step of rinsing the first substrate and before the step of treating the second substrate with the first excess portion of the flame retardant composition.

86. (New) The process of claim 85, wherein rinsing the first substrate includes spraying the rinse liquid onto the first substrate.

87. (New) The process of claim 79, wherein removing a first excess portion of the flame retardant composition from the first substrate includes using a centrifugation technique.

88. (New) The process of claim 79, wherein removing a first excess portion of the flame retardant composition from the first substrate includes squeezing the first substrate between two rollers.

89. (New) The process of claim 79, wherein removing a first excess portion of the flame retardant composition from the first substrate includes using a centrifugation technique.

90. (New) The process of claim 79, wherein removing a second excess portion of the flame retardant composition from the second substrate includes squeezing the second substrate between two rollers.

91. (New) A process for rendering substrates flame retardant, comprising the steps of:

applying a flame retardant composition to a substrate in a first vessel;
recovering a portion of said flame retardant composition which is not applied to said substrate during said applying step, said portion of said flame retardant composition being undiluted by rinse liquid and being free of dye or other contaminants;

drying said substrate to a desired moisture content; and

re-using said portion of said flame retardant composition by application to said substrate or another substrate.

92. (New) The process of claim 91 wherein said recovering step includes the step of physically separating a portion of said flame retardant composition from said substrate.

93. (New) The process of claim 92 wherein said physically separating step is achieved using at least one centrifuge.

94. (New) The process of claim 92 wherein said physically separating step is achieved by squeezing said substrate through mechanical rollers.

95. (New) The process of claim 91 wherein said recovering step includes the steps of

transferring a first amount of said portion of said flame retardant composition that is free flowing from a first vessel in which said applying step is performed after said step of applying to a second vessel; and

physically separating a second amount of said flame retardant composition from said substrate.

96. (New) The process of claim 95 wherein said physically separating step is performed in a third vessel.

97. (New) The process of claim 96 wherein said physically separating step is performed with at least one centrifuge.

98. (New) The process of claim 91 wherein said applying step impregnates said flame retardant composition into said substrate.

99. (New) A process for rendering substrates flame retardant, comprising the steps of:

applying a flame retardant composition to a first substrate in a first vessel and a second substrate in a second vessel;

recovering a first portion of said flame retardant composition which is not applied to said first substrate from said first vessel, and a second portion of said flame retardant composition which is not applied to said second substrate from said second vessel, said first and second portions of said flame retardant composition being undiluted by rinse liquid and being free of dye or other contaminants;

drying said first and second substrates; and

re-using said first and second portions of said flame retardant composition by transferring a first amount of said first portion to said second vessel and a first amount of said second portion to said first vessel for applying said flame retardant composition to said first or second substrates or one or more additional substrates, whereby said flame retardant composition used in said second vessel contains at least a portion of said flame retardant composition recovered from said first vessel which is undiluted by rinse liquid and is free of dye or other contaminants, and said flame retardant composition used in said first vessel contains at least a portion of said flame retardant composition recovered from said second vessel which is undiluted by rinse liquid and is free of dye or other contaminants.

100. (New) The process of claim 99 further comprising the step of physically separating a second amount of said portion of said flame retardant composition from at least one of said first substrate and said second substrate.

101. The process of claim 99 wherein said physically separating step is achieved using at least one centrifuge.